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Feed Efficiency and Growth Modeling of KUB Chicken: A Comparison Between Commercial and Alternative Feeds

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Abstract

Feed costs constitute a major expense in poultry production, emphasizing the need for efficient feeding strategies among smallholder farmers. The Ayam Kampung Unggul Balitbangtan (KUB) chicken is a promising native breed, yet limited research integrates feed efficiency with growth prediction modeling. This study evaluated commercial and alternative feed types while developing growth models. Twenty-five KUB chickens (~7 days old) were assigned to five dietary treatments: 100% commercial feed, 100% corn, 100% rice bran, 50% commercial + 50% corn, and 50% commercial + 50% rice bran, arranged in a completely randomized design with five replications. Body weight and feed conversion ratio (FCR) were recorded weekly for four weeks and analyzed using ANOVA. Nonlinear models (Exponential, Gompertz, Logistic) were applied for growth prediction. Feed type ($F = 14.30$, $p < 0.001$), week ($F = 292.68$, $p < 0.001$), and their interaction ($F = 3.53$, $p < 0.01$) significantly affected body weight. The mixed diet of 50% commercial feed and 50% corn produced the highest final weight (228.8 g), while corn and rice bran diets resulted in lower growth. Logistic models best described balanced diets, whereas Exponential models reflected nutrient-limited growth, providing predictive insights aimed at enhancing feed strategies for smallholder farmers.

Keywords: *KUB chicken; alternative feeds; growth performance; feed conversion ratio; growth modelling*.

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INTRODUCTION

Poultry farming is a vital part of animal husbandry, providing affordable protein and supporting rural lives (Olejnik et al., 2022; Gržinić et al., 2023). Local chicken breeds are preferred in Indonesia over broiler chickens due to their unique flavor, higher market value, adaptability, disease resistance, and cultural significance (Saragih et al., 2019; Sumantri, 2020). The Indonesian Agency for Agricultural Research and Development produced the Ayam Kampung Unggul Balitbangtan (KUB chicken), a major native breed advancement (Balitbangtan, 2014; Sartika & Iskandar, 2019). KUB chickens have faster growth, higher egg output, greater adaptability to local settings, and greater disease resistance (Insani et al., 2022).

However, poultry productivity depends most on feed management. Feed contributes for 60–70% of production expenses, and poor feeding techniques might reduce growth and profitability (Waithaka, 2022; Falowo et al., 2025). Commercial feed meets chicken nutritional needs and improves growth, but small–scale farmers cannot afford it (Afolayan et al., 2021). While rice bran and corn are cheap and abundant, they often lack the protein, energy, and micronutrients needed for optimal growth when fed alone (Biesek et al., 2020; Kafle et al., 2024). However, Fatwamaty & Harun (2025) found that village chickens fed moringa leaves, cassava leaves, and corn had superior body weight and egg production than commercial diet.

Assessing the efficacy of various feeding strategies necessitates the integration of biological and economic factors. Body weight gain and feed conversion ratio (FCR) serve as standard metrics for evaluating feed efficiency and growth performance in poultry science (Zampiga et al., 2021; Quintana–Ospina et al., 2023). These parameters, however, offer merely a limited view of performance. An enhanced methodology entails employing predictive growth models. Nonlinear models, including Exponential, Gompertz, and Logistic functions, are extensively utilized to characterize poultry growth. These models facilitate the estimation of asymptotic body weight, growth acceleration or deceleration rates, and overall growth potential (Mata–Estrada et al., 2020; Afrouziyeh et al., 2021). Integrating these models with feeding trials allows for the assessment of current performance and the prediction of future growth trajectories, providing valuable insights for production planning, feed formulation, and economic optimization.

Most research on chicken production has focused on broilers or other local breeds (Oryza et al., 2024), leaving few comprehensive studies on KUB. Feed efficiency and growth prediction are crucial. Few have integrated feeding tactics to predicted growth models, making it difficult to find cost–effective and efficient feeding solutions. This study examined KUB chicken growth and feed conversion ratio (FCR) on commercial, alternative (rice bran and maize), and combination diets to fill this gap. Predicting growth trajectories with exponential, Gompertz, and logistic nonlinear growth models helped KUB chicken farmers find the most efficient and sustainable feeding techniques.

RESEARCH METHODS

Time and Location

This study was conducted at the Experimental Farm of the Agricultural Engineering and Modernization Agency (BRMP), Kayu Agung, South Sumatra, Indonesia, from June to August 2025.

Research Design and Animals Housing

The experiment was arranged in a Completely Randomized Design (CRD) consisting of five dietary treatments, each replicated five times, resulting in a total of 25 experimental units. Each unit comprised five KUB chickens that were assigned to receive the designated feed treatment according to their respective group. The design and treatments were adapted, with modifications, from the procedure described by Sari et al., (2017). The diets consisted of 100% commercial feed, 100% corn, 100% rice bran, 50% commercial feed combined with 50% corn, and 50% commercial feed combined with 50% rice bran.

Data Collection

In this study, the body weight of KUB chicken was recorded weekly from the first to the fourth week. The average body weight gain was calculated for each dietary treatment. Subsequently, the Feed Conversion Ratio (FCR) was determined by dividing the total feed intake by the corresponding body weight gain for each treatment group throughout the experimental period. FCR was calculated following this formula (Rodde et al., 2020; Zhou e al., 2025):

$$\mathbf{FCR} = \frac{\textbf{Total Feed Intake (gr)}}{\textbf{Total Body Weight Gain (gr)}}$$

Data Analysis

All statistical analyses were done in R (4.4.2). With tidyverse, data was preprocessed and reshaped from wide to long (Wickham, 2016). Shapiro–Wilk and Levene's tests were used to determine the normality of body weight data at each week and feed group variance homogeneity (*car* package; Fox et al., 2013). Two–way ANOVA was used to investigate the impact of feed type, week, and their interaction on body weight at a significance threshold of α=0.05. If assumptions were not met, the Kruskal–Wallis test was used, followed by Dunn's post hoc test (*FSA* package; Ogle et al., 2015) at α=0.05. Pairwise comparisons of calculated marginal mean with Tukey adjustment (*emmeans* package; Lenth, 2017) revealed significant differences between treatments. One–way ANOVA at α=0.05 was used to compare feed conversion ratio (FCR) results across groups, with Tukey's HSD test for pairwise comparisons. Data on KUB chicken body weight and FCR were presented as Mean ± SE. To describe and predict growth trajectories, nonlinear least squares models (*nlsLM*, *minpack.lm* package; (Elzhov et al., 2022)) were fitted using Exponential, Gompertz, and Logistic functions, by following this equation:

Exponential model (Mirhoseini et al., 2018)

$$\boldsymbol{W_t} = \mathbf{a} \times \mathbf{e}^{(\boldsymbol{b} \times \boldsymbol{t})}$$

Gompertz model (Hifzan et al., 2024)

$$\boldsymbol{W_t} = \boldsymbol{A} \times \mathbf{e}^{-\boldsymbol{B} \times \boldsymbol{e}^{-\boldsymbol{k} \times \boldsymbol{t}}}$$

Logistic model (de Sousa et al., 2022)

$$\boldsymbol{W_t} = \frac{\boldsymbol{A}}{\mathbf{1} + \boldsymbol{B} \times \boldsymbol{e}^{-\boldsymbol{k} \times \boldsymbol{t}}}$$

with general notations (applies to all models):

W_t	:	body weight at week t
t	:	time (week)
A	:	asymptotic (maximum) body weight
B	:	constant related to the initial condition (curve position)
k	:	intrinsic growth rate parameter
a	:	initial body weight constant (used in the exponential model)
e	:	base of the natural logarithm (~2.718)

The model with the lowest Akaike's Information Criterion (AIC) and Root Mean Square Error (RMSE, *Metrics* package; Hamner & Frasco, 2012) was the best fit for each feed group (Hrehova et al., 2025; Portet, 2020). To visualize results, *ggplot2* (Wickham et al., 2007) was used to plot actual body weight observations, predicted growth curves, weekly body weight means, and FCR distributions among treatments.

RESULTS AND DISCUSSION

Growth Performance of KUB Chicken

Feed group, week, and interaction significantly affected KUB chicken body weight increase over four weeks. A two–way ANOVA (Table 1) revealed significant effects of feed group and week on chicken body weight ($F = 14.30$, $p < 0.001$ and $F = 292.68$, $p < 0.001$). A significant interaction between feed group and week ($F = 3.53$, $p < 0.01$) suggests that food regimen affects growth trajectory over time. These findings confirm previous research showing that feed composition, especially mixed or commercial diets, improves KUB chicken growth trajectories and that growth patterns change dynamically with age (Prasetyo et al., 2021; Hidayat, 2024).

Table 1. Two – way ANOVA for body weight of KUB chicken by feed group and week

Source of variaton	Df	F value	p – value	Interpretation
Treatment	4	14.30	<0.001	Highly significant
Week	3	292.68	<0.001	Highly significant
Feed group × Week	12	3.53	<0.01	Significant

Figure 1 shows KUB chicken weekly growth under different food regimes. While all groups gained weight over four weeks, feed type affected growth rate and final weight. KUB chicken fed Commercial 100% gained 43.8 g to 202.8 g, while Corn and Rice Bran 100% gained 153.2 and 165.8 g. Mixed diets, especially Commercial 50% + Corn 50%, produced the most weight (228.8 g), showing that corn or rice bran can promote growth, especially in later weeks. The significant feed–week interaction and these data suggest that feed type greatly affects growth trajectories.

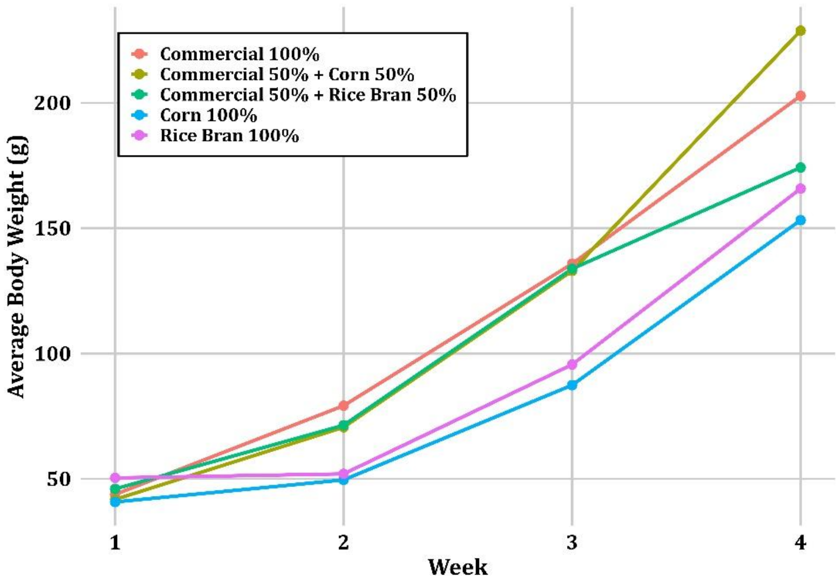

Figure 1. Growth of KUB chicken by feed group

KUB chicken growth differs due on feed type, composition and digestibility. Commercial feeds contain nutrients and additions to provide the necessary protein, energy, vitamins, and minerals for quick early growth (Geng et al., 2022; Ko et al., 2023). Single–ingredient feeds like maize or rice bran may lack important nutrients or have poor bioavailability, limiting growth (Lee et al., 2022). Mixed diets of commercial feed with maize or rice bran give enough energy and nutrients to stimulate growth in later weeks. Kim et al. (2019) found that supplementing broiler chicken given phosphorus–deficient diets with phytase improves development and bone characteristics. These findings stress the relevance of feed composition and nutritional balance for KUB chicken growth.

Tukey's HSD test (Table 2) revealed no significant differences in body weights among feed groups at Week 1, except for Chickens fed Rice Bran 100%, which had slightly higher beginning weights (50.4 ± 2.3 g). By Week 2, chicken fed Commercial 100% and mixed diets (Commercial 50% + Corn 50% and Commercial 50% + Rice Bran 50%) had higher body weights than Corn 100% and Rice Bran 100%, although the differences were not significant. KUB chicken on Commercial 100% and mixed feed regimens had higher body weights (Week 4: 202.8 ± 10.3 g, 228.8 ± 19.0 g, 174.2 ± 10.6 g) than those on Corn 100% (153.2 ± 4.8 g) and Rice Bran 100% (165.8 ± 5.5 g), indicating stronger growth promotion than single–ingredient diets. This suggests that mixed meals' higher nutrient density provides balanced nutrients to enhance growth during raising. Jia et al. (2024) also found that poultry fed high–nutrient–density meals have higher ADG and final body weights than those fed low–nutrient or single–ingredient diets. However, mixed meals optimized nutrients to guarantee chickens received all nutrients needed for rapid tissue development and metabolic processes, promoting accelerated growth (Barekatain et al., 2021).

Table 2. Post–hoc comparisons of feed groups (Tukey's HSD) for Body weight (g) of KUB chicken (mean ± SE) at differents week

Treatment	**Week**			
	1	**2**	**3**	**4**
Commercial 100%	43.8 ± 1.9 a	79.2 ± 4.0 ab	135.8 ± 11.0 b	202.8 ± 10.3 b
Corn 100%	40.8 ± 1.5 a	49.6 ± 3.0 a	87.4 ± 5.3 a	153.2 ± 4.8 a
Rice bran 100%	50.4 ± 2.3a	52.0 ± 2.7 a	95.6 ± 3.9 a	165.8 ± 5.5 a
Commercial 50% + Corn 50%	41.8 ± 4.0 a	70.6 ± 9.5 ab	133.0 ± 10.9 b	228.8 ± 19.0 c
Commercial 50% + Rice bran 50%	46.0 ± 3.7 a	71.4 ± 6.7 ab	133.8 ± 12.8 b	174.2 ± 10.6 bc

Abbreviation: Different superscript letters within a column indicate significant differences among feed groups at the same week (Tukey's HSD, $p < 0.05$).

Pairwise comparisons across weeks across each feed group (Table 3) showed progressive and significant body weight growth. Chicken fed Commercial 50% + Corn 50% showed significant weight gains, especially between Weeks 1 and 4 ($\Delta = 187.0$ g, $p < 0.0001$). However, Rice Bran 100% and Corn 100% groups gained less weight, and Week 1–2 intervals were not statistically significant. These findings suggest that feed composition impacts KUB chicken growth over time and body weight, with mixed and commercial feeds favoring quicker growth. Overall, feed type and age greatly affect growth performance, and judicious use of mixed or commercial feeds can optimize body weight gains in KUB chicken throughout early rearing.

Table 3. Pairwise comparisons of body weight changes across weeks within each feed group (Tukey's HSD, EMMeans)

Treatment	**Week Interval**					
	1–2	**1–3**	**1–4**	**2–3**	**2–4**	**3–4**
Rice bran 100%	−1.6 ns	−45.2 *	−115.4 ****	−43.6 **	−113.8 ****	−70.2 ****
Corn 100%	−8.8 ns	−46.6 **	−122.4 ****	−37.8 *	−103.6 ****	−65.8 ****
Commercial 100%	−35.4 *	−92.0 ****	−159.0 ****	−56.6 ***	−123.6 ****	−67.0 ****
Commercial 50% + Rice bran 50%	−25.4 ns	−87.8 ****	−128.2 ****	−62.4 ****	−102.8 ****	−40.4 **
Commercial 50% + Corn 50%	−28.8 ns	−91.2 ****	−187.0 ****	−62.4 ****	−158.2 ****	−95.8 ****

Abbreviation: Significance levels are denoted as follows: ns = not significant ($p \geq 0.05$), * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$, and **** = $p < 0.0001$.

Feed Conversion Ratio (FCR)

Table 4 shows the feed conversion ratio (FCR) of KUB chickens for each feed group, which measures feed usage efficiency for body weight gain. Mean FCR values varied from 1.16 ± 0.19 in Commercial 50% + Corn 50% to 1.79 ± 0.05 in Corn 100%. The Commercial 100% group had an intermediate FCR of 1.28 ± 0.09, whereas the Rice Bran 100% and Commercial 50% + Rice Bran 50% groups had 1.75 ± 0.09 and 1.73 ± 0.30, respectively. The one–way ANOVA showed numerical differences across feed groups, although they were not statistically significant ($F = 2.64$, $p = 0.06$, ns). Tukey's post–hoc test showed no feed group FCR difference. These findings imply that meal composition affected growth performance, but feed consumption efficiency was equal among treatments. KUB chickens retain stable FCR values under diverse feeding regimens if fundamental nutritional needs are addressed (Masir & Hadrawi, 2021; Prasetianti et al., 2025). Despite variations in mean FCR, all groups displayed similar feed efficiency, suggesting that, under the conditions of this study, none of the feed regimens significantly altered the conversion of feed to body weight in KUB chicken. This indicates that while growth rates differed among feed groups, feed utilization efficiency was relatively comparable across diets.

Table 4. Feed conversion ratio (FCR, mean ± SE) of KUB chicken by feed group

Treatment	FCR
Commercial 100%	1.28 ± 0.09 a
Corn 100%	1.79 ± 0.05 a
Rice bran 100%	1.75 ± 0.09 a
Commercial 50% + Corn 50%	1.16 ± 0.19 a
Commercial 50% + Rice bran 50%	1.73 ± 0.30 a
F count	2.64
p – value	0.06 ns

Abbreviation: ns = not significant ($p \geq 0.05$). Tukey grouping shows no significant differences among feed groups.

Predictability of Growth Models

Nonlinear growth models are widely applied to describe chicken growth trajectories, as they provide insights into biological growth potential and feeding strategy efficiency (Afrouziyeh et al., 2021; Mata–Estrada et al., 2020). Logistic fit Commercial 100% best (AIC = 172, RMSE = 14.8), followed by Gompertz in Table 5. This reinforces prior findings that Logistic and Gompertz models adequately characterize indigenous and commercial chicken growth patterns, which are sigmoidal with slow early growth, fast acceleration, and a plateau. Simpler Exponential and Logistic models showed linear and progressive weight rise with constrained asymptotic growth for chicken fed Corn 100%

and Rice Bran 100%. Due to their low nutritional density, single–ingredient meals impede growth and lower the sigmoidal development trajectory of balanced commercial diets. Logistic or Exponential models better simulate low–nutrient or single–ingredient diets, which limit rapid growth and large mature weights, according to Mata–Estrada et al. (2020) and Ferreira et al. (2021), in broilers fed sorghum, the Logistic model with exponential–type variance achieved the lowest AIC, surpassing more advanced models.

Mixed–feed growth patterns varied in complexity. Commercial 50% + Corn 50% had high AIC and RMSE values in all models, indicating growth unpredictability and limited predictability. This may indicate nutrition utilization variability or compensatory growth. In contrast, the Logistic model best suited the Commercial 50% + Rice Bran 50% group (AIC = 188, RMSE = 22.0), indicating sigmoidal growth despite variability. Van der Klein et al. (2020) suggest that chickens adapt growth rates to dietary shortages or imbalances. These results show that feed composition considerably impacts growth magnitude and mathematical growth paths. Logistic and Gompertz models can characterize chicken growth under nutritional balance, however Exponential models may perform better under nutritional limitations. KUB chicken growth dynamics depend on feed quality, as shown by the model's biological and nutritional effects (Narinç et al., 2017).

Table 5. Modeling Results of KUB Chicken Growth under Different Feeding Strategies Based on AIC and RMSE

Treatment	Model	AIC	RMSE
Commercial 100%	Exponential	173	15.6
Commercial 100%	Gompertz	173	14.8
Commercial 100%	Logistic	172	14.8
Corn 100%	Exponential	151	9.15
Corn 100%	Gompertz	157	9.96
Corn 100%	Logistic	153	9.15
Rice bran 100%	Exponential	160	11.3
Rice bran 100%	Gompertz	165	12.3
Rice bran 100%	Logistic	162	11.3
Commercial 50% + Corn 50%	Exponential	189	23.6
Commercial 50% + Corn 50%	Gompertz	191	23.6
Commercial 50% + Corn 50%	Logistic	191	23.6
Commercial 50% + Rice bran 50%	Exponential	189	23.3
Commercial 50% + Rice bran 50%	Gompertz	189	22.2
Commercial 50% + Rice bran 50%	Logistic	188	22.0

Note: Highlighted in yellow as the best model per treatment based on lowest value of AIC and RMSE.

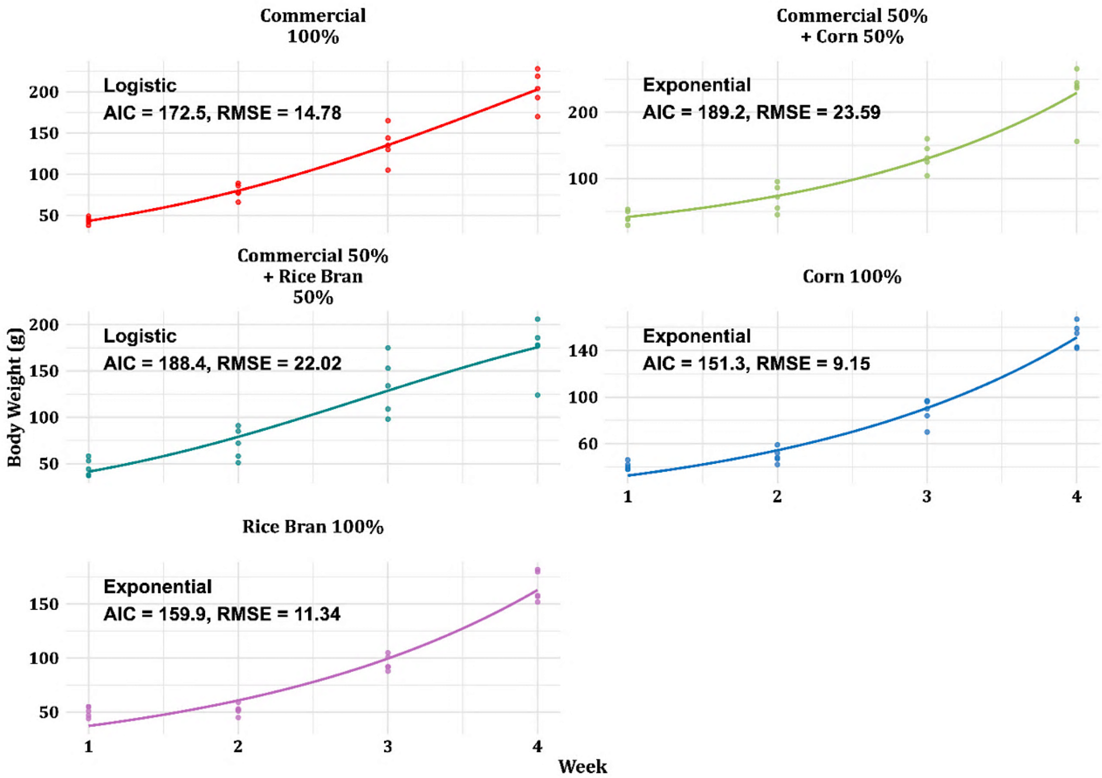

Figure 2. Growth curve of KUB chicken with best fit–models

Figure 2 shows the mean body weights and fitted curves for each feed group's best models. Modeling shows that growth dynamics are feed–dependent. These findings support recent reports that indigenous chicken grow model–dependently based on diet content (Narinç et al., 2017; Van der Klein et al., 2020). Thus, growth curve modeling provides a mathematical framework for forecasting performance under different feeding techniques and may help optimize KUB chicken feed formulas for growth efficiency.

The study provides two new KUB chicken growth insights. The results show that solely– and mixed–component diets induce distinct growth. Mixed diets and comprehensive commercial feeds promoted sigmoidal growth with elevated asymptotic weights, while pure maize and rice bran diets confined development to a virtually linear trajectory. This reveals that food mix greatly alters biological growth curve and rate. This study uses feed efficiency analysis and nonlinear modeling in KUB chickens to show that Logistic models reflect growth on nutrient–balanced diets and Exponential models on nutrient–limited diets. The results imply that dietary factors affect model selection, which could improve feeding operations by predicting. They provide a new paradigm combining feed composition, growth dynamics, and modeling suitability. Sustainable feed design for smallholder poultry systems is affected.

CONCLUSIONS

This study shows that feeding approach strongly affects KUB chicken growth performance and modeling. Mixed diets and complete commercial feed supported sigmoidal development trajectories better captured by Logistic models than solely–ingredient diets like maize or rice bran. This work is the first to combine feed efficiency analysis with nonlinear growth modeling in KUB chicken, showing that diet greatly affects model appropriateness. This shows that mixed feeding techniques, especially corn–commercial combinations, maximize body weight growth without sacrificing feed efficiency. This implies that corn–commercial mixed diets can boost KUB chicken output at low cost, giving smallholder farmers a sustainable feeding option.

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